MMSE SCFDE with Multi Antenna Transmit Diversity

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***Abstract*—SC block transmission by adding cyclic prefix is method with so many advantages. In this paper, we maintained the outage probability of MMSE receiver in cyclic delay diversity CP MISO flat fading channel with three transmit antenna. Also compare the CDD –CP and DD without CP system in 2x1 MISO flat fading channel so that in order to get maximum diversity. Our analysis compare the performance of zero forcing and MMSE receiver in 2x1 Alamouti transmission for block length L=4.**

***Index Terms*—SCFDE, Cyclic delay, Alamouti signaling, CDD, MMSE receiver.**

I. INTRODUCTION

SCFDE overcome the drawbacks present in OFDM system, such as peak to power average ratio (PAPR) [1]. SCFDE employ no FFT or IFFT at transmitter, but introduce cyclic prefix to transform the linear channel convolution into circular one. Here performance of SCFDE is characterized diversity as a function of transmission block length, data rates and number of channels. Also CDD transform spatial diversity into frequency diversity for avoiding intersymbol interference.

In this paper, we analyze the performance of SCFDE by using cyclic delay diversity (CDD) or Alamouti signaling for improving reliability of message signal by using two or more communication channel with different characteristics. From our analysis it shows that, at high data rates CDD diversity degenerates to the same diversity as that of SISO SCFDE but Alamouti signaling provides the diversity which is twice the diversity of SISO SCFDE.

A brief survey of related literature is as follows. In paper [2], Single-carrier frequency domain equalizationuses OFDM system.This paper provides low complexity and optimal solution for intersymbolinterference due to the multipath propagation. In survey [3], single-carrier

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diversity gain in frequency selective channels. SC-FDE has reduced sensitivity to the receiver. Diversity that is a function of data rate and transmission blocklength (hence the FFT size) which has been displays by SC-FDE in single-antenna (SISO) systems [3].

With the help of Orthogonal Frequency Division Multiplexing (OFDM), a dispersive channel converted into parallel subchannels and thus facilitates equalization[4]. With linearly precoded OFDM,design rules are provided in [4] to achieve maximumdiversity gains but it requiresML decoding.
In Precoded OFDM Systems, Maximum Multipath Diversity with Linear Equalization is proposed paper [5]. The zero-padded SC system withlinear equalization was analyzed in [6] where ZF equalizer is used to achieve full diversity.Theoretical Reliability of MMSE Linear Diversity and Rayleigh-Fading Additive Interference Channels are explained in [7].In OFDM, the Equivalence of Space-Time Block Coding with Multipath Propagation and Cyclic DelayDiversity is explained [8].

II. CYCLIC-PREFIX TRANSMISSION

A. SYSTEM MODEL

We consider a frequency selective wireless flatfading channel. A multipath model with $v + 1$ pathgive the equivalent baseband model for this intersymbol interference (ISI) channel. From that, channel vector is denoted by

h= $[h_0, . . . , h_v]$ (1)

Also the channel coefficients are independent and identically distributed ~*CN* (0, 1). Assume a block-fading model that has a channel which is fixed over the transmission block. At the receiver, a cyclic-prefix (CP) with length at least v is inserted at the beginning of each data-block of length$L$.Also to remove the inter-block interference, CP transforms linear convolution into circular convolution and therefore it permits channel diagonalization. For block transmission scheme with length-v CP, input-output system model is given as,

$$y = \sqrt{\rho} Hx + n \quad (2)$$

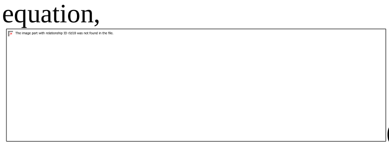
Where x - Transmitted signal
y – Received signal
n – Noise signal – $\sigma_n{}^2$
ρ - Transmitted signal power
H – Convolution channel matrix

B. THE DIVERSITY OF THE MMSE RECEIVER IN SC-FDE SYSTEM

For SC-FDE, the linear MMSE receiver is analyzed in [3], in that received signal after equalization is given by,

$\tilde{y} = Wy$ (3)

For certain values of block length & operating rate R b/s/Hz; full diversity is achieved by MMSE SCFDE.
The diversity of the MMSE SCFDEis given by equation,

(4)

III. CYCLIC-DELAY DIVERSITY

Antenna delay diversity is one of the common transmit diversity technique used for single carrier and multicarrier systems which can take the form of time delay, phase delay and cyclic delay [9], [10]. Cyclic delay diversity (CDD) is more widely adopted for single carrier and multicarrier applications as CDD can be applied to any number of transmit antennas without any rate loss or change in the receiver structure [8]–[11].

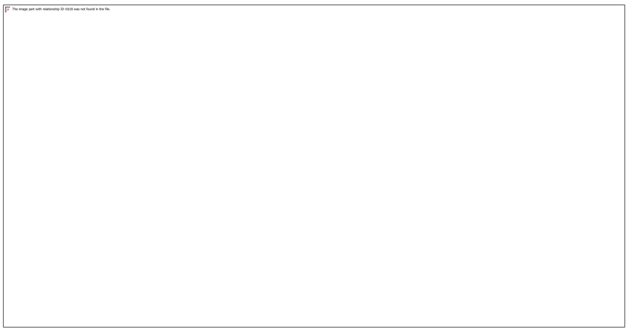


Fig.1. Single-carrier and multicarrier MISO system with transmitter
sided CDD scheme andproposed MMSE receiver.

A. System Model

From above diagram, we consider the MISO system with three transmits antennas and during block transmission channel remains unchanged. The channel impulse response from transmit antenna i to receiver antenna is given by,

$h_i=[h_i,0……….h_{i,vi}]$ (5)

Where $v_i$is the channel memory length.

Received signal is given in vector form,

$\sum_{i=0}^{M-1} \sqrt{\rho}\, H_i \hat{s}$i +n (6)

The outage probability of above system model is given by,

(7)

Where λk are the eigen values of Hcir.The 2*N Alamouti SCFDE can achieve full diversity 2N (v+1) and transmission rate is also below a certain threshold rate. The outage probability of MMSE Receiver is given by,

$Pout = P(\frac{1}{L} I_{MMSE} < R)$(8)

From this outage probability is achieved for MMSE receiver in flat fading channel with three transmit antenna.

IV. ALAMOUTI SIGNALING

The Alamouti is an another transmit diversity scheme.Alamouti signaling preserves the transmit diversity for above system model and because of that thus it provides a larger diversity gain compared with the CDD scheme. Frequency selective flat fading channel is consider for single carrier block transmission. In this, each data-block of length L is appended with a CP of length ν to eliminate interblock interference (IBI). The transmission scheme proposed is given as,

(9)

Where $X_i^{(k)}(n)$ is the symbol n of transmitted block k from antenna i. For even time slots, pairs of length-Nblocks $X_1^{(k)}(n)$ and $X_2^{(k)}(n)$ are generated. Thus diversity of 2x1 Alamouti signaling under MMSE SCFDE is given as,

(10)

Where L is the data block length.

This shows that, Alamouti SCFDE provides twice the diversity of SISO SCFDE.Thus diversity of 2xN Alamouti signaling under MMSE SCFDE is given as,

(11)

We consider zero forcing equalizer for Alamouti transmission. The outage probability for zero forcing equalizer is given as,

(12)

Fig. 2. Transmission scheme proposed by [5] for communication over
frequency-selective fading channels.

V. SIMULATION RESULTS

Figure 3 shows the original channel impulse response. Figure 4 shows the outage probability Pout for the MMSE receiver in the CDD CP MISO flat fading channel with 3 transmit antennas, for cyclic delay of d0=1,d1=2 & d2=4.Figure 4 compare the performance of zero-forcing and MMSE receivers for 2x1 Alamouti transmission for block length L=4.The diversity of ZF is 2 for all rates R, where the diversity of MMSE is greater than or equal to depending on the value of rate R. The diversity of ZF CDD is 1 whereas the diversity of the ZF Alamouti is 2. The diversity of ZF equalizer and MMSE receiver is independent of R.

Fig 3. An original channel impulse response

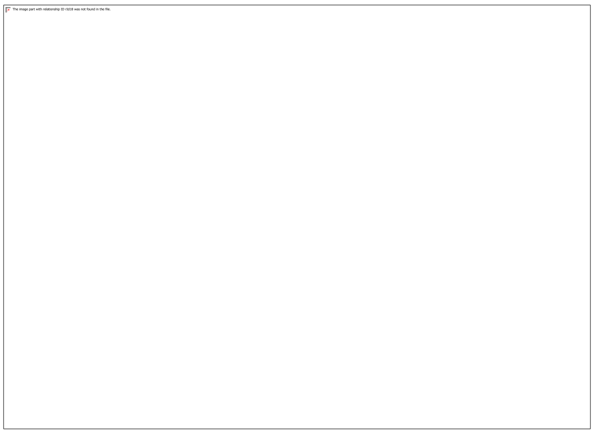


Fig. 4. The outage probability of AWGN channel impulse response, ZFE response & MMSE receiver.

VI. Conclusion

This paper uses two diversity techniques: cyclic delay diversity (CDD) and Alamouti signaling to analyze single carrier frequency domain equalizer (SCFDE). In this we perform the analysis to achieved maximum diversity. Also we check the outage probability Pout of MMSE Receiver in CDD CP MISO flat fading channel with 3 transmit antennas. In this paper, we also compare the performance of zero forcing & MMSE receiver in 2x1 Alamouti transmission for block length L=4. From this we get,the diversity of ZF CDD is 1 whereas the diversity of the ZF Alamouti is 2.

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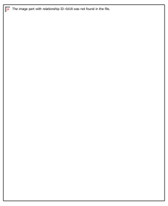

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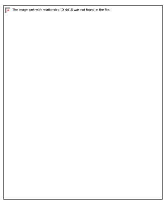

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